Field Implementation of Nuclear Safeguards: ENEA' s Capability Projection-17174

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ABSTRACT

The Non-Proliferation Treaty (NPT) for Italy entered into force on May 2nd 1975, in the framework of the national political position to deal with the nuclear energy only for civilian medical and industrial uses, being the country included in the NNWS (Non-Nuclear Weapon States). It is recognized that for these scopes nuclear material is produced, used, shipped and disposed, but it is at the same time known that it is not like any other material. The signature of further international treaties like the Additional Protocol to NPT led the Italian Ministry for the Economic Development (MISE) to take advantage of the public Italian Agency for Energy Environment and the Economic Development (ENEA) by means of a three years basis renewable agreement that could support the Ministry in fulfilling the clauses and obligations rising from the treaty itself and then fostering R&D in the field of the safeguards.

MISE supported the procurement of a mobile laboratory able to bring sophisticated analysis instruments on the field in case of suspected environmental contamination deriving from the presence of nuclear materials. The description of this mobile laboratory and its capabilities is illustrated in this paper.

INTRODUCTION

Italy through the act n. 332 October 1st 2003 [1] ratified the Additional Protocol to the Non-Proliferation Treaty which actually includes 188 countries and it commits the NWS (Nuclear Weapon States) not to provide nuclear weapons or nuclear explosive devices to the NNWS (Non-Nuclear Weapon States), these must not to acquire nuclear weapons, accepting safeguards on all nuclear material. All the States parties agree in an export controls regime to facilitate the technology exchange and to pursue negotiations on nuclear disarmament [2].

The Additional Protocol to the NPT extends the control actions to materials and activities which are not specifically nuclear, but that may direct or indirect be used in the nuclear field. Furthermore, the collection of information on these materials and activities is widened, also the verification and inspections on use, eventual presence of undeclared materials, adoption of new control systems and a better coordination.

The art. 3, paragraph 2, of the above mentioned law indicates ENEA, the Italian Agency for Energy, the Environment and the Sustainable Economic Development, as one of the bodies to which MISE (the Italian Ministry of the Economic Development) can entrust the execution of studies and analysis and other specific activities related to the AP (Additional Protocol).

MISE and ENEA agreed that the most appropriate instrument to undertake the activities in this scenario was a so-called “Convention” that was signed for the first time on October 6th 2004, to be renewed on three years basis provided the approval of an agreed technical program [3].

Since 2004, ENEA was entrusted by MiSE both for the fulfilment of the obligations of the Additional Protocol that completes the NPT and to the improvement of the country’s capacity in the field of the nuclear safeguards. ENEA is the Agency that in Italy has peculiar capacity and knowledge in the nuclear field, starting from the beginning of the implementation of this technology in the Italian scenario.

The Convention includes the submittal of a three years based action program which can start after Ministry’s approval and is specified year by year. In the program 2014, the procurement of a special dedicated vehicle was proposed and approved. This vehicle was intended to include all the instruments for field analysis in case of finding of radioactive items that could result harmful for the population and the environment.

ENEA Agency has assigned the task of giving specific analytical service for qualitative and quantitative analysis of unidentified and suspicious materials.
The characterization of the nuclear material is performed by the staff of the of Nuclear Materials Characterization Laboratory of ENEA directly involved, by its own means and their own instrumentation, on the site with the mobile laboratory.

If necessary, the sample can be transported, after a first radiological characterization, to the Nuclear Materials Characterization Laboratory operated at ENEA Casaccia Research Center for the execution of additional measurements not achievable using portable or transportable measurement techniques.

The mobile laboratory was specially designed to undertake “in situ” analysis on the wide spectrum of possible cases of intervention and the multiplicity of types with which components and suspicious radiological materials may arise, especially in case of loss of traceability and in the event of improper storage at intermodal shipment points (ports, airports or railway stations), waste controls or environmental samples containing fissile or radioactive material.

Fig.1: The ENEA Mobile Laboratory

Several types of instruments can be transported by the mobile laboratory. This being the adaptation of a commercial vehicle customized for these needs. At the same time field training sessions, instrument calibrations, and procedures optimization are also expected to be carried out.

DESCRIPTION

The presence of "suspect" material alert the various actors in emergency management: the discovery of a "suspicious" material requires the coordinated action of more bodies and organizations to carry out complex tasks like:

- urgent intervention to limit risks to the population and the environment;
- identification and evaluation of the radioactive material;
- on site remediation and safe management of the material to be identified;
- investigative activity, where the substance has been the subject of theft.

The Agency ENEA is involved for the radiological characterization of the material to be identified.

The objective of the radiological characterization is the identification and quantification of emitters radionuclides in nuclear material in order to make a proper management of material to be controlled.
The material to be identified is initially characterized in situ, using portable and/or transportable instrumentation.
The operations performed during the first phase of finding and sample identification can be summarized as follows:
a) verify the integrity and visual examination of the sample;
b) acquisition of photographic images of the sample;

c) measure the size and weight of the sample;
d) measurement of beta / gamma and neutron contact dose rate;
e) measurement of surface contamination by "smear test".
The next phase consists in the real radiological characterization of the material to be identified that can be articulated as follows:
f) identification of the radioisotopes present in the sample;
g) evaluation of the activity of the sample and, possibly, the specific activity (with the relative measurement uncertainties);
h) assessment of the physical state of the sample and its size in order to identify the type of container suitable for transport in accordance with national and international regulations.
The instrumentation used for the purposes mentioned above is of a portable type or transportable.

It is essentially a version of an utility vehicle of common commercial production and is equipped for the characterization on site of radioactive materials. In the rear part a mobile platform is installed to have an easy handling of the ISOCS (In Situ Object Counting System) system, which is described as follows.

In the central part a counter was provided with the housings of the instrumentations and a radiochemical fume hood that allows the confinement of the suspected samples.

The instrumentation which is fitted inside the mobile laboratory was acquired in the previous years of the Convention, and it is essentially based on the following equipment:

Radiochemical fumehood. This device is installed in the technical volume of the van and allows to safely manage small samples guaranteeing the operator and environmental protection from eventual risks of contamination. The fume hood includes an aspiration and filtering system by means of an electrical motor, allows the confinement of the sample for further analysis at the Nuclear Materials Characterization Laboratory operated at ENEA Casaccia Research Center.

Fig. 2: Radiochemical Fume hood

***ISOCS*. (In Situ Object Counting System)**. The In Situ Object Counting System (ISOCS) developed by Canberra, Inc. is the portable, in-situ gamma spectroscopy system, to identify radioactive isotopes and to qualitatively determine the amount of radioactive material in the considered sample.

The ISOCS system operates with a characterized Germanium detector with portable cryostat; a cart support for holding the detector, lead shielding and collimators; an InSpector portable spectroscopy analyzer; a portable computer with Genie-PC software; and the ISOXSW in situ calibration software. The detector is a HPGe (High Purity Germanium) detector (active volume: diameter 60 mm and 25 mm thickness) whose response to a series of point sources surrounding it has been characterized using a Monte Carlo code. Its typical measurement time ranges from 30 min to a couple of hours according to the experimental conditions.

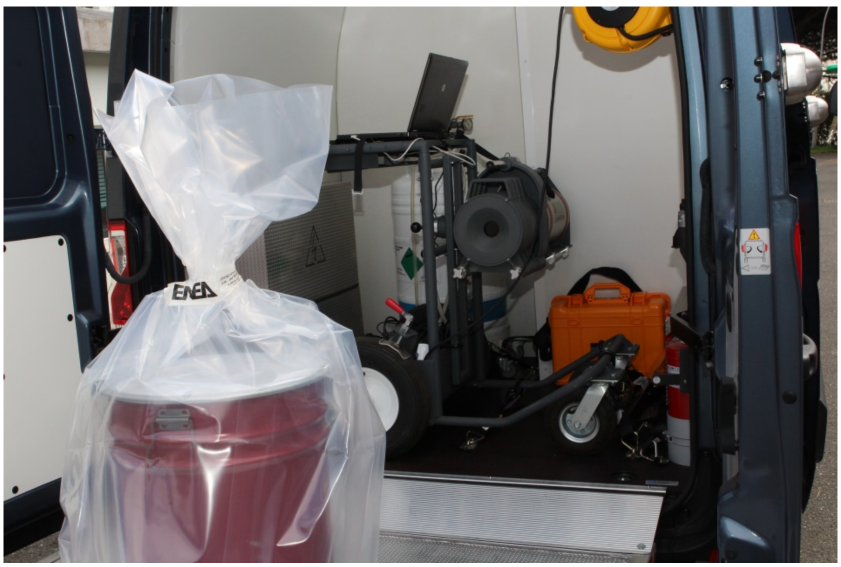

Fig.-3: ISOCS System

Portable Instrumentation

Inspector 1000. It is a portable system that uses a neutron probe and a □ radiation detector.

Fundamental components:

- GM detector. Internal Geiger-Muller detector for high-doses measurements;
- □ scintillation probe LaBr – 1.5” x 1.5” 8 000 cps/mrem/ h ±3.5% at 662 keV (Cs137);
- Neutron probe – External detector ^{3}He (active length 8 cm – 2 atm); intrinsic neutron sensitivity ≈1%;.

This instrument can be easily used for radionuclides identification, □ spectra acquisition and analysis and neutron detection.

LP 123P Berthold Plutonium Monitor. Portable system, designed to achieve the maximum efficiency in the detection of fission neutrons. It assesses also quantitatively the presence of Plutonium. It is possible, in fact, thanks to a ^{3}He detector to know the plutonium mass (in terms of $^{240}Pu_{eff}$) in a few seconds. As an example, the device is able to detect a “weapon grade” plutonium quantity<100 g.

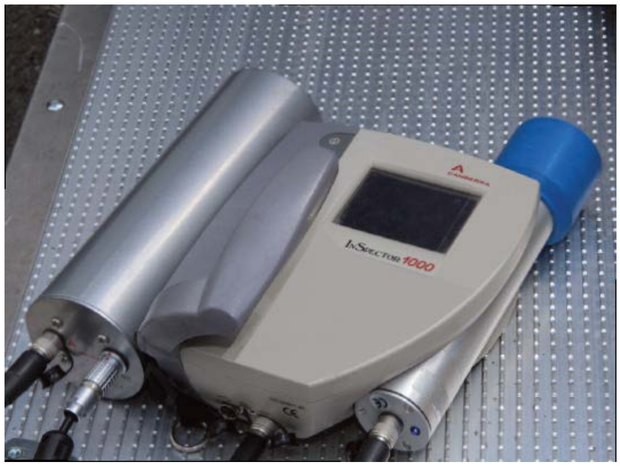

Fig. 4: Inspector 1000

NT 200. It is used to evaluate an eventual surface contamination. It is a portable analyzer for on filter “smear test” measurements and in air contamination. It is equipped with a proportional Ar-CO_2 meter and it is able to measure separately □ and β radiations and to subtract actively the background radiation with a separate detector.

Fig.5: NT 200

*SSNC, **S**mall **S**amples **N**eutron **C**ounter*. Transportable system for □ contaminated materials based on passive neutron techniques. It includes a double array of ^{3}He detectors connected to a Neutron Coincident Counter, for the measurement of the fissile mass in small dimensions samples.

The neutrons emitted by the source (e.g. a sample containing fissile material) are thermalized through a thick high-density polyethylene, and detected as proton emissions obtained by the nuclear reaction ^{3}He (n, p) ^{3}H in ^{3}He detectors.

Time correlation methods of the signals generated in the detectors (Neutron Coincidence Counting and Neutron Multiplicity Counting) are applied to count only neutrons generated by spontaneous fission of some isotopes of fissile/fertile materials for safeguards application.

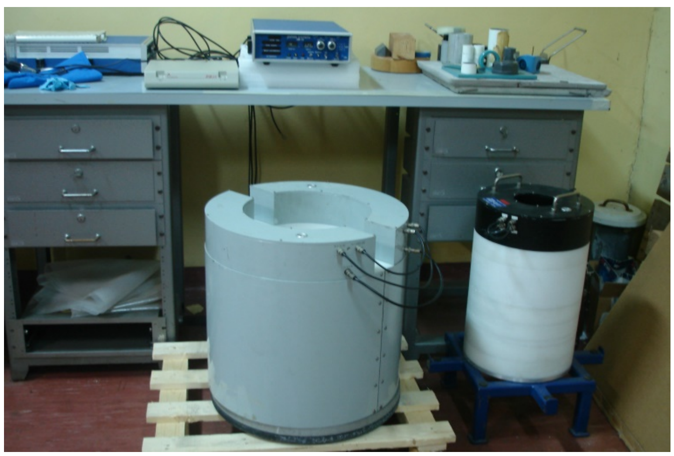

Fig. 6: SSNC ***S**mall **S**amples **N**eutron **C**ounter*

Teletector 6112M. It is an instrument that measures dose and dose rate and thanks to its steel telescopic probe that can be extended up to 4 m, is able to measure the gamma and beta radiations emitted by the sample ensuring the safety of the operator.

Fig. 7: Teletector 6112 M

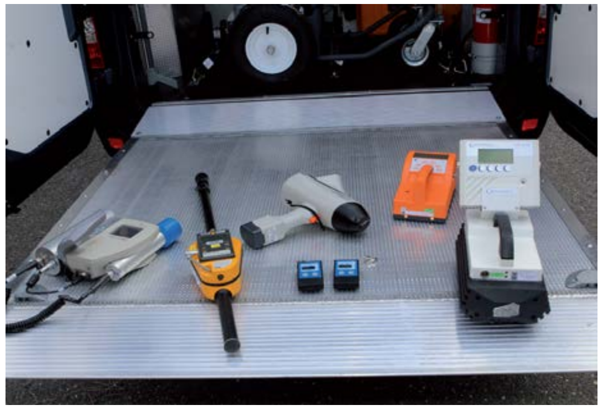

Fig. 8: Portable Instrumentation

CONCLUSIONS

The safeguards system consists of a list of items and activities, including specific legislation, agreements and regulations, collection and assessment of information, studies, facilities and administrative systems. Among them, the Verification Agreement of 1973 between the IAEA, EURATOM and the Member States, through which the States accepted the checks on all materials used in nuclear activities on their territories, in order to verify that nuclear materials are not "diverted" towards nuclear weapons manufacturing.

An effective system of nuclear safeguards, however, depends on proper planning, training, consciousness, operation and maintenance of the system itself. The Additional Protocol to the Non-Proliferation Treaty, ratified in Italy by Law 332/2003, aims to the strengthening of control actions of facilities and nuclear materials, foresees checks both on technologies and components that, even if basically for conventional use, could be used for nuclear weapons manufacturing, and on the exports to other countries.

Checks' effectiveness of "sensible exports" determines the actual capacity of the safeguards system to find enforcement and compliance, and requires collaboration by all stakeholders, both from government and private (exporters).

The key element of a strategy to avoid use of nuclear material by terrorists is to protect and possibly reduce or eliminate the presence of nuclear weapons and fissile material.

All radioactive materials must be monitored and protected: the line of defense is the detection of illicit traffic of nuclear material or other radioactive materials across borders or within a state. To secure the material it must firstly be located: it is needed to activate a massive monitoring program of goods and people along all the borders of national territory.

The procurement of the mobile laboratory that has been customized through an accurate and coordinate work between different units is an appropriate step for the implementation of the safeguards, since the Country signed all the International Protocols for the control of nuclear materials and to face the threats deriving from the suspect use of these materials.

The inclusion of the mobile laboratory in the last three-years program Convention ENEA-MISE was a good point to enhance the system. An accurate diagnosis through a reliable and complete instrumentation, operated by trained and long experienced personnel, gives more guarantees that the safeguards are implemented.

The special authorization for the transport of radioactive materials (ADR) which the Radiochemical Mobile Laboratory is going to obtain will allow a radiological complete characterization of the “suspect” sample carried out in the Nuclear Materials Characterization Laboratory of ENEA Casaccia Research Center if the in-situ characterization is incomplete.

Furthermore the ADR authorization will allow to use on site a newly designed Non Destructive Assay equipment [4] developed at the Nuclear Materials Characterization Laboratory that, by means of a neutron generator coupled with neutron and gamma measurement systems, allows the identification of dirty bombs or buried materials containing fissile radioisotopes.

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